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# Methodological proposal for qualitative assessment of Geoheritage

## *Proposta metodológica para avaliação qualitativa do Geopatrimônio*

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**Abstract:** Research aiming at the qualitative evaluation of geomorphological heritage has lacked a more detailed discussion and standardization of evaluation. The present text presents a technical note that exposes a selection method and a proposal for an inventory of the geomorphological heritage that was elaborated after reviewing specialized literature on the subject. The inventory form was useful for the development of field activities for four master's theses in this research group. It is expected that diffusion of the inventory may subsidize other works that carry out qualitative evaluation of the geomorphological heritage in the academic and technical environment.

**Keywords:** Geodiversity; Geopatrimony; Geomorphopatrimony; Geosites.

**Resumo:** Considera-se que as pesquisas que visam a avaliação qualitativa do patrimônio geomorfológico carecem de maior discussão e padronização de avaliação. Apresenta-se no presente texto uma nota técnica, que expõe um método de seleção e uma proposta de inventário do patrimônio geomorfológico, elaborada após revisão da literatura especializada no tema. A ficha de inventário realizada foi útil ao desenvolvimento das atividades de campo de quatro dissertações de mestrado desse grupo de pesquisa. defendidas e tendo mérito destacado pelas bancas avaliadoras. Espera-se que a sua difusão através da Revista de Geociências do Nordeste possa subsidiar outros trabalhos que realizam avaliação qualitativa do geomorfopatrimônio no meio acadêmico e técnico.

**Palavras-chave:** Geodiversidade; Geopatrimônio; Geomorfopatrimônio; Geossítios.

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## 1. Introduction

Geodiversity is a concept that has been systematized and developed in the last three decades and addresses the diversity of elements and processes in the abiotic environment. Works by Gray (2004) and Brilha (2005) were extremely important in disseminating the notion of geodiversity and are now global references on the subject, which has already made important theoretical and methodological contributions and is increasingly gaining ground in academic circles.

Evaluations on geodiversity, whether qualitative or quantitative, show that proposals to quantify abiotic environments have made considerable progress in relation to inventory proposals. In general, they establish a value/score to distinguish sites that deserve greater or less attention depending on their scientific, touristic, cultural, educational and economic importance, among others.

There are generally two main notions within society's concept of heritage: one is cultural and the other, natural. The latter is understood by UNESCO (1972, p.02) as including:

> Natural monuments consisting of physical and biological formations or groups of such formations of outstanding universal value from an aesthetic or scientific point of view; geological and physiographic formations and strictly delimited areas which are the habitat of endangered animal and plant species of outstanding universal value from the point of view of science or conservation; sites of natural interest or strictly delimited natural areas of outstanding universal value from the point of view of science, conservation or natural beauty.

Natural heritage, understood as the symbiosis between geodiversity and biodiversity, can be compartmentalized into a number of focus areas, such as Geoheritage, aimed at valuing the abiotic environment, which includes the geological, geomorphological, hydrological and speleological heritage, etc. The aim of geomorphological heritage, or geomorpho-heritage, is the study of landforms of exceptional value (scientific, touristic, cultural, educational, economic, among others) within the area of Geoheritage (CLAUDINO-SALES, 2018, 2021).

Among the main proposals for the quantitative assessment of Geoheritage, some of which are restricted to geomorphic heritage, we can mention works by Panizza (2001), Coratza and Giusti (2005), Pralong (2005), Pereira (2006), Reynard (2006), Gray, Gordon and Brown (2013), Reynard et al. (2016), Brilha (2016), and Lopes (2017). It should be noted that works by Gray (2004), Brilha (2005) and Pereira (2010) are also the basis for various methodologies that were developed, although they are more general and focus on geological heritage.

Though they play a key role in helping to select sites of interest - pointed out as a *sine qua non* condition in several works, such as those by Brilha (2005), Reynard (2006), Gray (2013); Reynard et al. (2016) - proposals for qualitative assessments of geodiversity sites of interest have not been developed in the same way as quantitative assessments, both in scale and depth.

Therefore, since there is a general opinion that proposals dealing with the qualitative assessment or inventory of Geoheritage as a whole has been inadequate, there is a consensus that groundwork for inventorying geomorphological heritage, especially suited to the reality of tropical regions, is needed. Hence, the continuous process of inventorying the geodiversity of a given locality is a fundamental stage for the development of geoconservation proposals, especially regarding geomorphological heritage.

With the abovementioned points in mind, the research group which the authors are a part of is presenting a proposal for the qualitative assessment of geomorphological heritage sites of interest. It is expected that a methodological basis will be achieved, one which, in its qualitative assessment, can address natural aspects in a holistic way and can enable the qualification of plural sites, whether they refer to the characteristics of the site itself or to the geographical situational factors in which they are located.

## 2. Methodology

The full evaluation methodology consists of three main stages: site selection, qualitative evaluation and quantitative evaluation. This text, however, focuses on the first two stages, which were organized as a form divided into seven tables related to the general themes to be assessed, seventeen topics for the themes, and seventy-two subtopics related to specific relevant characteristics.

The result shown below is a compilation of various criteria that have been brought to light by some of the leading researchers in the field, such as Brilha (2005), Pereira (2006), Reynard (2006), Brilha (2016), Reynard et al. (2007), Pereira (2010), Reynard et al. (2016), Lopes (2017) and Rabelo (2018). In addition, it was used geomorphological information

seen in the work of Souza (2000), including the insertion of the method developed by Santos et al. (2020) for selecting sites of interest, with an adaptation in central values. The form is comprehensive, ranging from the location of the site to possible risks to tourists, and is divided into 14 sections. These are Site Selection; Characterization of Geomorphological Heritage; General Framework; Preliminary Assessment; Legal Status; Current Use; Potential Use; Geological Phenomena - Sedimentary Processes; Abiotic Ecosystem Services; Geomorphological Qualification; Other Landscape Components; Landscape Analysis; Degree of Knowledge; Safety and Site Understanding Tools. Therefore, the technical note addresses a qualitative selection and evaluation method for geomorphological heritage.

## 3. Results and discussion

The first stage consists of choosing the sites using an adaptation of the Santos et al. (2020) method, shown in Table 1. Based on the work by Brilha (2016), the authors emphasized that the sites need to be both scientifically relevant and have the potential for educational and touristic use. However, the core parameters here are the scientific and aesthetic aspects (Points 1.4 and 1.5). Therefore, if a site obtains more than 50% of the evaluation in core parameters and 75% in additional ones, it will be considered for a preliminary list in the second stage and points 2 and 3 will be considered as ancillary to the site.

*Table 1 – General description of the Geomorphodiversity identification form.*

| CRITERIA | EVALUATION |
|---|---|
| **1. CENTRAL PARAMETERS** | |
| **1.1. Representativeness** | 1 - Low/2 - Medium/3 - High/4 - Very High |
| **1.2. Integrity** | 1 - Low/2 - Medium/3 - High/4 - Very High |
| **1.3. Rarity** | 1 - Low/2 - Medium/3 - High/4 - Very High |
| **1.4. Scientific Knowledge** | 1 - Low/2 - Medium/3 - High/4 - Very High |
| **1.5. Aesthetic Relevance** | 1 - Low/2 - Medium/3 - High/4 - Very High |
| **2. ADDITIONAL PARAMETERS** | |
| **2.1. Ecological Relevance** | 0 - None/ 1 - Low/2 - Medium/3 - High |
| **2.3. Cultural Relevance** | 0 - None/ 1 - Low/2 - Medium/3 - High |
| **3. USAGE AND MANAGEMENT PARAMETERS** | |
| **3.1. Accessibility** | 1 - Low/2 - Medium/3 - High |
| **3.2. Security** | 1 - Low/2 - Medium/3 - High |
| **3.3. Infrastructure** | 1 - Low/2 - Medium/3 - High |
| **3.4. Visibility** | 1 - Low/2 - Medium/3 - High |

*Source: Adapted from Santos et al. (2020)*

Items 1, 2, 3, 4, 5, 6 and 7 (Table 2) were criteria taken from the points of interest identification form in Rabelo's work (2018), which, in turn, was adapted from Brilha's proposal (2005). However, adaptations were made and new parameters inserted, such as points 1.2 (geoforms); 5.3 (existence of trails), highlighting the function of the trail (5.3.1), its classification (5.3.2) according to Andrade's methodology (2003), and the level of difficulty (5.3.3) corresponding to the

ICMBio guidelines (2011). Next, in 6.1, based on the 2018-2022 National Tourism Plan (BRASIL, 2018), the tourism category was discussed and, finally, in 7.1, the age of the rocks in the geoforms were inserted by the authors.

*Table 2 – General description of the Geomorphodiversity identification form.*

| **1. CHARACTERIZATION OF GEOMORPHOLOGICAL HERITAGE** | | |
|---|---|---|
| **POINT N°:** | **NAME/MUNICIPALITY:** | **DATE:** |
| **GEOGRAPHICAL COORDINATES:** | | **ACCESS:** |
| **1.1. ACCESSIBILITY** | ( ) Easy - Direct access by paved road | **1.2. LOCAL GEOFORMS** |
| | ( ) Moderate - Access by paved roads, complemented by carriageways of up to 10 km. | |
| | ( ) Difficult Accessible only by carriage roads over 10 km long. | |
| **2. GENERAL FRAMEWORK** | | |
| **2.1. TYPOLOGY** | ( ) Plutonic | |
| | ( ) Volcanic | |
| | ( ) Metamorphic | |
| | ( ) Sedimentary | |
| **2.2. ADDITIONAL CHARACTERIZATION ITEMS (Y -YES; N -NO):** | Geomorphology: ( ) Y ( ) N | |
| | Stratigraphic: ( ) Y ( ) N | |
| | Paleontology: ( ) Y ( ) N | |
| | Tectonic: ( ) Y ( ) N N or Neotectonic ( ) Y ( ) N | |
| | Hydrogeological: ( ) Y ( ) N | |
| | Mineralogical: ( ) Y ( ) N | |
| | Geochemistry: ( ) Y ( ) N | |
| | Petrological: ( ) Y ( ) N | |
| | Miner: ( ) Y ( ) N | |
| | Museums and collections: ( ) Y ( ) N | |
| **3. PRELIMINARY ASSESSMENT** | | |
| **3.1 MAGNITUDE OF SITE** | ( ) Site [<0.1 ha] | |
| | ( ) Place [0.1 - 10 ha] | |
| | ( ) Zone [10 - 1000 ha] | |
| | ( ) Area [>1000 ha] | |
| | ( ) Panoramic | |
| **3.2 OBSERVATION CONDITIONS** | ( ) Good - No obstacle to the visibility of geoforms | |
| | ( ) Satisfactory - With some obstacles, but not enough to interfere in seeing the geoforms | |
| | ( ) Regular - Presence of obstacles that make it difficult to see the geoforms. | |
| | ( ) Bad - Geoforms that are only visible in situ due to the amount of obstacles that prevent them from being fully visualized. | |
| **4. LEGAL STATUS - LOCATION** | | |
| **4.1 SUBJECT TO PRESERVATION/LEGAL CONSERVATION** | ( ) Direct | If so, which one (APA, PPA, Park, etc.)? |
| | ( ) Indirect | |
| | ( ) No protection | |
| **5. CURRENT USE** | | |
| ( ) Rural ( ) Forest ( ) Agricultural ( ) Touristic ( ) Industrial Zone ( ) Urbanized ( ) Other. Which? | | |

| | | |
|---|---|---|
| **5.1 ADMINISTRATIVE SITUATION** | ( ) Site located in areas of restricted access and public property | |
| | ( ) Site located in areas of restricted access and private property | |
| | ( ) Site located in open access areas (public or private property) | |
| **5.2 OBSTACLES FOR USE OF SITE** | **( ) No obstacles** | |
| | **( ) With obstacles - close to:**<br>**( ) Without obstacles** | ( ) Industries |
| | | ( ) Deposits |
| | | ( ) Urban areas |
| | | ( ) Fences |
| | | ( ) Trails |
| | | ( ) Other. Which ones? |
| **5.3 EXISTENCE OF TRAILS** | ***5.3.1*** **Track function** | ( ) Short distance |
| | | ( ) Long distance |
| | ***5.3.2*** **Trail classification** | ( ) Circulate |
| | | ( ) In eight |
| | | ( ) Linear |
| | | ( ) Shortcut |
| | ***5.3.3*** **Level of difficulty of trail** | ( ) Low |
| | | ( ) Medium |
| | | ( ) High |
| | | Description of physical conditions: |
| **6. POTENTIAL USE** | | |
| ( ) Touristy ( ) Scientific ( ) Economic ( ) Didactic | | |
| **6.1 IF TOURISTIC, WHAT KIND?** | ( ) Cultural/Religious | ( ) Sport |
| | ( ) Adventure | ( ) Geotourism |
| | ( ) Ecotourism | ( ) Reserach |
| | ( ) Sun and beach | Other: |
| **7. GEOLOGICAL PHENOMENA** | | |
| **7.1 AGE OF ROCKS** | ( ) Precambrian | |
| | ( ) Paleozoic | |
| | ( ) Mesozoic | |
| | Cenozoic: ( ) Paleogene ( ) Neogene | |
| | Quaternary: ( ) Holocene ( ) Pleistocene<br>Geoforms: | |
| | ( ) Other: | |
| **7.2 LITHOLOGY** | ( ) Terrigenous | |
| | ( ) Non-terrigenous | |
| **7.3 PRESENCE OF SEDIMENTARY STRUCTURES** | **( ) Yes**<br>**( ) No** | Which ones? |
| **7.4 CRYSTALLINE ROCKS** | **( ) Yes**<br>**( ) No** | Which ones? |
| **7.5 FOSSILS** | **( ) Yes**<br>**( ) No** | Which ones? |

*Source: Adapted from Andrade (2003), Brilha (2005), ICMBio (2011), Brasil (2018) and Rabelo (2018).*

Item 8 (Table 3) was incorporated from the proposal to define abiotic ecosystem services, using the methodology developed by Gray (2013), Gray, Gordon and Brown (2013), Gordon and Barron (2013), Hjort et al. (2015), Gordon (2018).

*Table 3 – Abiotic Ecosystem Services in the Geomorphological Heritage.*

| **8. ABIOTIC ECOSYSTEM SERVICES IN GEOMORPHOLOGICAL HERITAGE** | | |
|---|---|---|
| **SERVICES** | **CATEGORIES/BENEFITS** | **CONTRIBUTION AND BENEFITS OF GEODIVERSITY RESOURCES AND/OR PROCESSES** |
| **8.1. REGULATION** | **8.1.1. Climate regulation** | **Direct: ( )<br>Indirect: ( )<br>Absent: ( )** |
| | **8.1.2. Air Quality Regulation** | **Direct: ( )<br>Indirect: ( )<br>Absent: ( )** |
| | **8.1.3. Water Regulation** | **Occurs: ( )<br>Absent: ( )** |
| | **8.1.4. Water Quality/Water purification and waste treatment** | **Direct: ( )<br>Indirect: ( )<br>Non-use: ( )** |
| | **8.1.5. Flood control** | **Direct: ( )<br>Indirect: ( )<br>Absent: ( )** |
| | **8.1.6. Atmospheric and oceanic regulation** | **Direct: ( )<br>Indirect: ( )<br>Absent: ( )** |
| | **8.1.7. Natural Hazards and Erosion Regulation** | **Occurs: ( )<br>Absent: ( )** |
| **8.2.PROVISION** | **8.2.1. Fresh water supply** | **Direct: ( )<br>Indirect: ( )<br>Absent: ( )** |
| | **8.2.2. Industrial Materials** | **Direct: ( )<br>Indirect: ( )<br>Absent: ( )** |
| | **8.2.3. Energy (renewable and non-renewable)** | **Direct: ( )<br>Indirect: ( )<br>Absent: ( )** |
| | **8.2.4. Nutrients and minerals for healthy growth** | **Direct: ( )<br>Indirect: ( )<br>Absent: ( )** |
| | **8.2.5. Ornamental resources** | **Present: ( )<br>Absent: ( )** |
| | **8.2.6.Building materials** | **Direct: ( )<br>Indirect: ( )<br>Absent: ( )** |
| | **8.2.7. Food, fiber, fuel, biochemicals, pharmaceuticals and natural remedies (through nutrients provided by the soil).)** | **Indirect: ( )<br>Absent: ( )** |
| **8.3. CULTURE AND KNOWLEDGE** | **8.3.1. Cultural diversity** | **Direct: ( )<br>Indirect: ( )** |

| | | |
|---|---|---|
| | | **Absent: ( )** |
| | **8.3.2. Spiritual and religious values and cultural meanings** | **Direct: ( )**<br>**Indirect: ( )**<br>**Absent: ( )** |
| | **8.3.3. Knowledge systems** | **Direct: ( )**<br>**Indirect: ( )**<br>**Absent: ( )** |
| | **8.3.4. Education** | **Direct: ( )**<br>**Indirect: ( )** |
| | **8.3.5. Artistic inspiration** | **Indirect: ( )**<br>**Absent: ( )** |
| | **8.3.6. Aesthetics** | **Direct: ( )**<br>**Indirect: ( )** |
| | **8.3.7. Social relations** | **Direct: ( )**<br>**Indirect: ( )**<br>**Absent: ( )** |
| | **8.3.8. Sense of place** | **Direct: ( )**<br>**Indirect: ( )**<br>**Absent: ( )** |
| | **8.3.9. Cultural heritage and Geoheritage** | **Direct: ( )**<br>**Indirect: ( )** |
| | **8.3.10. Environmental quality** | **Direct: ( )**<br>**Indirect: ( )**<br>**Absent: ( )** |
| | **8.3.11. Recreation and nature-based Tourism** | **Direct: ( )**<br>**Indirect: ( )**<br>**Absent: ( )** |
| **8.4. SUPPORT** | **8.4.1. Soil formation processes** | **Direct: ( )**<br>**Indirect: ( )**<br>**Absent: ( )** |
| | **8.4.2. Burial and storage** | **Direct: ( )**<br>**Indirect: ( )**<br>**Absent: ( )** |
| | **8.4.3. Platform for human activity** | **Direct: ( )**<br>**Indirect: ( )**<br>**Absent: ( )** |
| | **8.4.4. Biogeochemical cycling** | **Direct: ( )**<br>**Indirect: ( )**<br>**Absent: ( )** |
| | **8.4.5. Habitat Provision** | **Direct: ( )**<br>**Indirect: ( )**<br>**Absent: ( )** |

*Source: Adapted from Gray (2013); Gray, Gordon e Brown (2013), Gordon e Barron (2012); Hjort et al. (2015); Hjort et al. (2015), Gordon (2018).*

Table 4 represents items 9 and 10, inserted based on Souza's (2000) proposal, which includes geomorphological characteristics. The type of site (9.1) was used according to studies by Figueró, Vieira and Cunha (2014) and Claudino-Sales (2018; 2019). In addition to the aforementioned items, color contrast (9.3.1) and verticality (9.3.2) were added, since these criteria, according to the authors, help determine spectacularity, a useful item for understanding the site's aesthetic value. Item 9.6, residual features, was adapted from the concepts set out in the work developed by Maia et al. (2018).

*Table 4 – Geomorphological characteristics.*

| **9. GEOMORPHOLOGICAL QUALIFICATION** | | | |
|---|---|---|---|
| **9.1. TYPE OF SITE** | **9.1.1. Shapes** | **Coastal** | ( ) Cliffs |
| | | | ( ) Bays and coves |
| | | | ( ) Cables and coastline |
| | | | ( ) Linear beach |
| | | | ( ) Arches |
| | | **Tectonics** | ( ) Folding structures |
| | | | ( ) Failed structures |
| | | **Neotectonics** | ( ) Folding structures |
| | | | ( ) Failed structures |
| | | **Plutonic** | ( ) Intrusive structures |
| | | **Volcanic** | ( ) Eruptive structures<br>( ) Dikes<br>( ) Veins |
| | | **Erosive forms in sedimentary structures** | ( ) Ruiniform relief |
| | | | ( ) Plateaus and tablelands |
| | | | ( ) Canyons and depressions<br>( ) Cuesta<br>( ) Glint |
| | | **River** | ( ) Abandoned meander |
| | | | ( ) Waterfalls and cascades |
| | | **Derived from weathering** | ( ) Weathering in intrusive structures |
| | | | ( ) Pseudo karst structures |
| | | **Glaciers** | ( ) Glacial valleys<br>( ) Fjords |
| | **9.1.2. Deposits** | **Wind** | ( ) Dune field |
| | | | ( ) Paleodunes |
| | | | ( ) Loess |
| | | **Marine/Fluvial marine** | ( ) Sandbanks and sandy bars |
| | | | ( ) Reefs<br>( ) Lagoons<br>( ) Marine Terraces |
| | | **Fluvial** | ( ) River islands |
| | | | ( ) Floodplain |
| | | | ( ) Terraces |
| | | | ( ) River bars and alluvial fans<br>( ) Delta<br>( ) Estuary |
| | | **Glaciers** | ( ) Moraines |
| | | | ( ) Erratic blocks |
| | | | ( ) Glaciers |
| | | | ( ) Till |
| | | **PREDOMINANT IN THE AREA:** | |
| | ( ) A - 0 a 3% Flat terrain | | |

| | | | |
|---|---|---|---|
| **9.2. PREDOMINANT SLOPE CLASS ON THE SITE** | ( ) B - 3 a 8% Gentle undulating terrain | | |
| | ( ) C - 8 a 20% Undulating terrain | | |
| | ( ) D - 20 a 45% Strongly undulating terrain | | |
| | ( ) E - 45 a 70% Steep terrain | | |
| **9.3. SPECTACULARITY** | ***9.3.1*** **COLOR CONTRAST** | | **( ) Yes ( ) No** |
| | ***9.3.2*** **VERTICALITY (>50 m)** | | **( ) Yes ( ) No** |
| **9.4. DISSECTION FEATURES** | ( ) Hill | | |
| | ( ) Crest | | |
| | ( ) Peak | | |
| | ( ) Plateau | | |
| | ( ) Escarpment | | |
| **9.5. DEPOSITION FEATURES** | ( ) Plain - Specify | | |
| | ( ) Colluvium | | |
| | ( ) Delta | | |
| | ( ) Beach | | |
| | ( ) Barrier | | |
| **9.6. RESIDUAL FEATURES** | **( ) Yes ( ) No** | **9.6.1. MACROFORMS** | ( ) Inselberg |
| | | | ( ) Testimonial |
| | | | ( ) Crest |
| | | | ( ) Escarpment |
| | | | ( ) Lajedo |
| | | | ( ) Bornhardt |
| | | **9.6.2. MICROFORMS** | ( ) Caves |
| | | | ( ) Cornice |
| | | | ( ) Boulder |
| | | | ( ) Castle Koppies |
| | | | ( ) Block Chaos |
| | | | ( ) Tors |
| | | | ( ) Tafoni |
| | | | ( ) Honeycomb |
| | | | ( ) Karren |
| | | | ( ) Gnammas |
| | | | ( ) Split Rock |
| | | | ( ) Poligonal Cracking |
| | | | ( ) Pedestal Rock |
| | | | Other: |
| **9.7. APPARENT MORPHODYNAMIC PROCESSES** | **9.7.1. Weathering** | | **( ) Yes ( ) No** |

| | | |
|---|---|---|
| | | |
| | **9.7.2. Rain action** | **( ) Yes ( ) No** |
| | **9.7.3. Mass movements** | **( ) Yes ( ) No** |
| | **9.7.4. Fluvial processes** | **( ) Yes ( ) No** |
| | **9.7.5. Aeolian Processes** | **( ) Sim ( ) Não** |
| **10. OTHER COMPONENTS OF THE LANDSCAPE** | | |
| **10.1. SURFACE HYDROLOGY** | **( ) Yes ( ) No** | Name of river and catchment area: |
| **10.2. SOILS AND SURFACE FORMATIONS** | **10.2.1. Nature of Material** | ( ) Eluvial |
| | | ( ) Coluvial |
| | | ( ) Alluvial |
| | | ( ) Marine |
| | | ( ) Wind |
| | **10.2.2. Soil class** | Type |
| | **10.2.3. Mulch** | |
| | **10.2.4. Soil erosion** | ( ) Runoffr |
| | | ( ) Laminar |
| | | ( ) Grooves |

| | | |
|---|---|---|
| | | ( ) Ravines |
| | | ( ) Fluvial |
| | | ( ) Marine |
| | | ( ) Wind |
| | | ( ) Deflation |
| | | ( ) Other |
| **10.3 CHARACTERISTICS OF LAND USE AND OCCUPATION** | | |

***Source**: Adapted from Souza (2000), Figueró, Vieira e Cunha (2014) e Claudino-Sales (2018), Claudino-Sales (2019).*

Item 11 (Table 5) is related to landscape analysis where the geoforms of the sites of interest are found, using, as criteria, the Ecodynamics of the Media (item 11.1) by Tricart (1977), morphogenesis (item 11.2) by Reynard (2006) and, finally, the anthropogenic risk (11.3) by Reynard et al. (2016).

*Table 5 – Landscape analysis*

| **11. LANDSCAPE ANALYSIS** | |
|---|---|
| **11.1. MEDIA ECODYNAMICS** | ( ) Stable Environment |
| | ( ) Transitional environment with a tendency towards stability |
| | ( ) Transitional environment prone to instability |
| | ( ) Highly unstable environment |
| | **PREDOMINANT IN THE AREA:** |
| **11.2. MORPHOGENESIS:** | |
| **11.3. ANTHROPOGENIC RISK** | ( ) Site without human interference. |
| | ( ) Site with little human interference (Indirect interference). |
| | ( ) Site with direct anthropic interference, but no risk of deterioration. |
| | ( ) Site with strong anthropogenic interference and imminent risk of degradation/destruction. |

***Source**: Adapted from Tricart (1977), Reynard (2006) and Reynard et al. (2016).*

Item 12 corresponds to the degree of knowledge, dealing with both the didactic potential and the scientific production of the sites of interest analyzed. Items were adapted from Pereira (2010) and Brilha (2016), seen in Table 6.

*Table 6 – Level of knowledge*

| **12. LEVEL OF KNOWLEDGE** | | |
|---|---|---|
| **12.1. TEACHING POTENTIAL** | **( ) Yes ( ) No** | ( ) Superior |
| | | ( ) High School |
| | | ( ) Elementary school and general public |
| **12.2. SCIENTIFIC PRODUCTION** | **( ) Yes ( ) No** | ( ) Books |
| | | ( ) Theses |
| | | ( ) Dissertations |
| | | ( ) Monographs |
| | | ( ) Scientific articles |
| | | ( ) Other. Which? |

*Source: Adapted from Pereira (2010) and Brilha (2016).*

Items 13 and 14 (Table 7) were taken from the proposal by Reynard et al. (2016), referring to safety and tools for understanding the Site. The topic of safety refers to the possible risks that a geotourist would be exposed to when visiting

a particular site of interest, whether natural or man-made. The tools for understanding the site aim at describing the conditions related to the spontaneous ability to understand the site on one's own, by means of facilitating instruments.

*Table 7 – Security items and tools for understanding the site.*

| | | |
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| **13. SECURITY** | | |
| **13.1. NATURAL RISKS (landslides, altitude, uneven trail, etc.)** | ( ) There is no risk to visitors. | |
| | ( ) Presents up to 01 risk to visitor. | Risk: |
| | ( ) Presents up to 02 risks to visitor. | Risk: |
| | ( ) Presents more than 02 risks to visitor. | Risk: |
| **14. SITE UNDERSTANDING TOOLS** | | |
| **14.1. INTERPRETIVE INFRASTRUCTURE** | ( ) lack of mechanisms to facilitate understanding. | |
| | ( ) Presence of some means of helping the visitor understand the site. | Type: |
| | ( ) Presence *in situ* (signs, panels, totems). | Type: |
| | ( ) Presence in *situ/ex situ* (plaques, panels, totems, book, magazine, website). | Type: |

*Source: Adapted from Reynard et al (2016).*

Table 8 shows a database which should be used as a manual at a conceptual and practical level and was drawn up to help understand items on the Geomorphodiversity identification form.

*Table 8 – Geomorphodiversity Database*

| **GEOMORPHODIVERSITY DATABASE - GLOSSARY** | | |
|---|---|---|
| **Geoforms** - "The different shapes of the Earth's surface (or geoforms) characterize the relief that is the result of the action of forces or agents that have acted for millions of years" (CPRM, 2008, p. 137). | | |
| **GENERAL FRAMEWORK** | | |
| **TYPOLOGY** | **Plutonic** - Igneous rock consolidated at great depths. | |
| | **Volcanic** - Originates from the consolidation of magmatic material leaked onto the Earth's surface during eruptions. | |
| | **Metamorphic** - The result of the transformation of other pre-existing rocks. | |
| | **Sedimentary** - The result of chemical precipitation, the deposition of debris from other rocks or the accumulation of organic debris. | |
| **ABIOTIC ECOSYSTEM SERVICES** | | |
| **Provision Service** - Responsible for making material goods available to human societies. It is the easiest to understand since, in most cases, it has a monetary value associated with the good, which is then treated as a product. | **Freshwater supply** - Geology provides the fabric for aquifers and supports surface water systems. Soils, underground geology and topography influence the potential for surface water storage, while aquifer properties influence the potential for groundwater storage and production. | **Direct:** natural sources of fresh water from surface water or groundwater; also mineral water. Surface or groundwater abstraction for public, industrial or private domestic supply.<br>**Indirect:** a source to sustain water-dependent habitats and maintain base flow to rivers.<br>**Absent:** No evidence. |
| | **Industrial Materials** - The resources of the abiotic environment are responsible for providing the raw materials and inputs that | **Direct:** The exploitation of resources used in industry takes place on the site.<br>**Indirect:** Incipient exploitation takes place on the site, with reserves of raw |

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| | are fundamental to the functioning of industries. | materials that could be used in industry in the future.<br>**Non-use:** There are no industrial resources. |
| | **Energy (renewable and non-renewable)** - Geology, topography and natural processes help provide renewable forms of energy (hydroelectric, geothermal, tides, waves and wind) and non-renewable ones (coal, oil, natural gas, etc.). | **Direct:** The abiotic environment directly, and with high potential, provides the supply of energy resources.<br>**Indirect:** The abiotic environment provides the basis for energy exploitation, but with limited potential.<br>**Absent:** Does not provide the means for energy exploitation |
| | **Nutrients and minerals for healthy growth** - Minerals and nutrients are generally obtained from food at considerable levels, and food in turn obtains these from the soil. | **Direct:** The typology of the soil, added to the mineralogical particularities are determining factors for adequate growth or a certain activity.<br>**Indirect:** The aspects of the soil have an influence on a particular activity.<br>**Absent:** There is no relationship. |
| | **Ornamental resources** - Supply of rocks, fossils, minerals and aggregates for decoration and landscaping. | Examples include precious stones, precious and semi-precious metals, granite worktops and slate floors in kitchens, rocks and river stones in gardens, paving slabs and slate, fossils, polished stones and minerals for household ornaments. |
| | **Construction materials** - Extraction of rocks, sediments and other materials for civil construction. | **Direct:** The extraction of fundamental inputs for construction takes place: sediment, rock, sand, water.<br>**Indirect:** The exploitation of materials linked to construction takes place for its operation. Example: extraction of limestone for cement production.<br>**Absent:** There are no links. |
| | **Food, fiber, fuel, biochemicals, pharmaceuticals and natural remedies (through nutrients provided by soils)** - Food products derived from plants, animals and microbes; fiber products, including wood, jute, cotton, hemp, silk and wool; wood, manure and other biological materials; many medicines, biocides, food additives such as alginates and biological materials are derived from ecosystems. | **Indirect:** Through nutrients supplied by soils.<br>**Absent:** No food, fibers, fuels, biochemicals, pharmaceuticals and natural remedies (through nutrients supplied by soils) |
| **Regulation Service** - Processes that aim to naturally control environmental conditions, be it air, water or soil.<br>It controls the availability, quantity and quality of these resources. | **Climate regulation** - Geodiversity influences climate locally and globally (for example, through the effects of topography on temperature and precipitation). Geological and geomorphological processes and soils play a fundamental role in regulating the climate through the weathering of rocks, carbon sequestration and the release of greenhouse gases. | **Direct:** The characteristics of the geosites determine some climatic particularities.<br>**Indirect:** The physical characteristics of the geosites have a slight influence on the local climate.<br>**Absent:** No influence of any kind. |

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| | **Regulating Air Quality** - Ecosystems contribute and extract chemicals from the atmosphere, influencing many aspects of air quality. | **Direct:** The physical characteristics of the environment have a direct influence on air quality.<br>**Indirect:** Some characteristics of the geosites perform services that influence air quality.<br>**Absent:** No influence of any kind. |
| | **Water regulation** - The timing and magnitude of runoff, flooding, water storage and aquifer recharge can be strongly influenced by topography, soil, superficial deposits and bedrock. | **Examples:** contribution to natural hazard mitigation (q.v.), water quality (q.v.), provision of drinking water (q.v.) and provision of habitats and recreational opportunities (e.g. water sports). |
| | **Water Quality/Water purification and waste treatment** - Rock, superficial deposits and soil act as natural filters, providing the "fabric" for regulating water quality. The unsaturated zone (soil and subsurface geology that purifies percolated water) filters out particles, organic waste and other pollutants before they reach groundwater storage. This service recognizes the capacity of geodiversity components and processes to contain, dilute, attenuate and decompose pollutants. | **Direct:** economic benefits through reduced subsequent requirements for water supply treatment.<br>**Indirect:** "cleaner" water for inland aquifers and surface water bodies and their dependent habitats.<br>**Non-use:** aesthetic benefits of unpolluted bodies of water. |
| | **Flood control** - Flood control is often listed as an ecosystem service, but many of the processes involved are physical and ecological. For example, soil and subsoil sediments absorb large amounts of rainwater and thus reduce surface runoff, i.e. delay, and smooth the delivery of rainwater to river channels, thereby reducing flooding. | **Direct:** The particularities of the abiotic environment play a fundamental role in reducing the impacts of flooding.<br>**Indirect:** There is a tenuous influence on reducing the impacts of flooding, sharing it with the biotic environment.<br>**Absent:** No influence of any kind. |
| | **Atmospheric and Oceanic Regulation** - Atmospheric and oceanic circulations play a vital role in regulating the world's climate and habitability. | **Direct:** The abiotic environment and concomitant geomorphological aspects play a determining role in atmospheric and oceanic regulation.<br>**Indirect:** There is some influence on atmospheric and oceanic circulation and, consequently, on climate, habitats and living conditions.<br>**Absent:** No influence of any kind. |
| | **Natural Hazards and Erosion Regulation** - Protecting people, property and land from natural hazards such as flooding, erosion and landslides. | **Examples:**<br>- River flood regulation through natural forms of flood defense and flooding of natural floodplains and/or anthropogenic excavations (such as quarries);<br>- Protection from river and floodplain erosion and protection from sediment deposition by maintaining natural channel flows and sediment regimes;<br>- Regulation of coastal flooding through the natural migration of the sea inland and |

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| | | protection by natural forms of flood defense (salt marsh, sand dunes);<br>- Coastal erosion protection through the maintenance of dunes and beach elevations and natural sediment circulation;<br>- Slope and soil erosion protection and risk assessment through analysis of rock and soil properties, slope stability and past patterns of process activity. |
| **Support Services** - Services in which geodiversity provides resources for the development of human activities or nature itself and which depend directly on soils and rocks to be carried out. It includes the provision of resources for certain human activities and the planet's biota. | **Soil formation processes** - The rate of soil formation through weathering of rocks and other parent materials (including those derived from erosion and sediment deposition) is a key factor in providing a medium for plant growth and supporting habitats. | **Direct:** Soil formation is a determining factor in the establishment of healthy ecosystems.<br>**Indirect:** many supply services depend on soil formation and fertility. |
| | **Burial and storage** - The physical resources of the earth have long been used for human burial, placing bodies in the earth (as in graves) or in monuments built above ground, such as pyramids or - on a smaller scale - stone mounds or dolmens. A diverse range of rock types are also used by modern stonemasons to make gravestones (Figure 4.3), although an important property here is durability, especially in retaining inscriptions. | **Direct:** Used for nuclear waste storage, burial or as raw material for building mausoleums.<br>**Absent:** There are no relations. |
| | **Platform for human activity** - - Geodiversity provides a platform for construction and infrastructure (for example, flat terrain on raised beaches or river terraces). | **Direct:** Economic benefits.<br>**Absent:** No relationship. |
| | **Biogeochemical cycling** - The continuous natural circulation of vital elements (e.g. carbon and nitrogen), comprising exchanges between the atmosphere, the geosphere and living organisms. | **Direct:** Supply of minerals and nutrients necessary for the cycle to function.<br>**Indirect:** supporting the function and integrity of other ecosystem services. |
| | **Habitat Provision** - The physical environment generally plays a huge role in providing habitats for biodiversity, but this seems to be rarely recognized by ecologists. | **Direct:** The physical environment determines the characteristics of the habitat.<br>**Indirect:** The physical environment has an influence on the habitat. |
| **Cultural and Knowledge Service** - Society's relationship to some abiotic aspect of the environment because of its social or community significance. The knowledge service is related to proposals for | **Cultural diversity** - The diversity of the physical environment is a factor that influences the diversity of cultures and cultural identity. | **Indirect:** Has an influence on local cultural particularities.<br>**Absent:** There is no relationship. |
| | **Spiritual and religious values and cultural meanings** - Natural rock formations and landfills often have religious or spiritual values associated to them, included in local folklore and legends. | **Indirect:** Has an influence on local cultural particularities.<br>**Absent:** There is no relationship. |

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| using abiotic nature as a classroom and laboratory as well, with its exploitation being purely scientific and educational. | | |
| | **Knowledge systems** - Society benefits from knowledge of the Earth's physical properties, materials, processes and history in many ways (e.g. through applied geology, engineering and environmental geology, medical geology and geophysics). Records of past climatic and environmental changes preserved in a variety of archives (e.g. ice cores, ocean sediments, landforms and lake sediments) allow a long-term perspective on Earth system processes and ecosystem dynamics, trends and human interactions. They provide baselines for environmental monitoring and forecasting, and can indicate possible ecosystems, responses to future changes in climate and other factors. | **Direct:** Environmental peculiarities constitute a good example and/or provide fundamental input for knowledge systems.<br>**Indirect:** Environmental peculiarities provide some support for knowledge systems.<br>**Absent:** There are no relationships. |
| | **Education** - Geodiversity provides the basis for both formal and non-formal education for people of all ages, through learning and outdoor learning opportunities. | **Direct:** Environmental peculiarities are a good example and can be used for education at all levels, whether primary, secondary or higher.<br>**Indirect:** Environmental peculiarities provide examples and can be used for higher education. |
| | **Artistic inspiration** - Geodiversity provides a rich source of inspiration for art, literature, poetry, music, sculpture, national symbols, architecture and built heritage and gardens. | **Direct:** There are bibliographies, evidence and reports that geodiversity has been a source of inspiration.<br>**Absent:** There are no reports/evidence of artistic inspiration. |
| | **Aesthetics** - Many people find natural beauty and aesthetic value in various aspects of the natural environment, scenic landscapes and views, interesting/beautiful/dramatic landscapes and silence/tranquility/peace. | **Direct:** Aesthetically rich and pleasant landscape.<br>**Indirect:** Landscape that stands out for a point, not necessarily being spectacular. |
| | **Social relations** - Changes in ecosystem services (e.g. freshwater availability, flood regulation or erosion) can affect social relations, particularly in cultures that have maintained strong links to their local environments. Volunteering through Local Geoconservation Groups can also provide opportunities for social interaction. | **Direct:** Ecosystem services play a fundamental role in the functioning of nearby society.<br>**Indirect:** Ecosystem services have considerable influence on the functioning of society.<br>**Absent:** There is no relationship. |
| | **Sense of place** - Many people value the sense of place that is associated with the recognizable features of their environment, such as natural rock formations and landscapes, and the perceived "sense of security" is a characteristic created by these features. | **Direct:** Place appreciated by residents and visitors.<br>**Indirect:** Place for visitors. |
| | **Cultural Heritage and Geoheritage** - Geosites associated with major | **Direct:** The site has relevance in more than one parameter. |

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| | developments in geoscience are part of the cultural value of Geoheritage. Other geosites are significant for their historical, literary or artistic associations or other cultural significance. Geodiversity underpins the landscape and seascape character and different types of cultural landscape. The use of local or traditional stone and other geological materials within the built environment and the conservation of cultural landscapes contribute to the cultural heritage of an area and its landscape character. Cultural memories are often expressed through natural features such as mountains, waterfalls and rock formations. | **Indirect:** The site is relevant in a specific parameter. |
| | **Environmental quality** - Geodiversity and Geoheritage contribute to the environmental quality that supports people's health and well-being. | **Direct:** The site plays a determining role in environmental quality.<br>**Indirect:** The site has an influence on environmental quality. |
| | **Recreation and nature-based Tourism** - People often choose where to spend their leisure time based on the natural features or cultural characteristics of a particular area. Physical features (geodiversity) underpin the landscape character, valued habitats and ecosystems, and the aesthetic and other cultural qualities of an area. They provide opportunities for outdoor recreation (e.g. hiking, rock climbing, caving, skiing and outdoor adventure) and leisure, or a quiet haven in which to relax and reflect, and contribute to people's health and well-being. They also support geotourism, which in turn provides a source of employment (e.g. in geoparks) and a range of relational and other benefits described above that contribute to people's health and well-being and to their lifelong educational and personal development. | **Direct:** The site is the main destination for recreational activities for the local population and usually receives some tourists.<br>**Indirect:** The site is commonly used for recreation.<br>**Absent:** The site is not used for recreational activities. |

| **CURRENT USE** | | |
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| **EXISTENCE OF A TRAIL** | **TRAIL FUNCTION** | **Short-distance** - Recreational and educational, with a program designed to interpret the natural environment. |
| | | **Long-distance** - The experience of the visitor who is looking to travel through large wild spaces is valued, such as cross-country trips. |
| | **TRAIL CLASSIFICATION** | **Circular** - The circular trail offers the possibility of returning to the starting point without repeating the route on the way back. It is also possible to define a single direction of use for the trail, which allows visitors to follow the route without passing other visitors in the opposite direction. |

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| | | **In eight** - These trails are very effective in limited areas, as they increase the possibility of using these spaces. |
| | | **Linear** - This is the simplest and most common trail format. Its purpose is usually to connect the main path, when it is no longer the main path, to a destination such as lakes, glades, caves, peaks, etc. It has the disadvantages of being the same as the outward route and for the possibility of passing other visitors going in the opposite direction. |
| | | **Shortcut** - This type of trail starts and ends at different points from a main trail or path. Despite the name, the aim of the shortcut trail is not to "cut through", but to show an alternative area to the main trail or path. |
| | **LEVEL OF DIFFICULTY** | **Low** - Requires little or no physical conditioning or technical skills. |
| | | **Medium** - Requires regular physical conditioning and knowledge of basic technical skills. |
| | | **High** - Requires excellent physical fitness and mastery of technical skills. |

**GEOMORPHOLOGICAL CLASSIFICATION**

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| **TYPE OF SITE** | **FORMS** | **COASTAL** | **Cliffs** - a term used interchangeably to refer to abrupt or steep coastal landforms, or similar unevenness in the interior of the continent. |
| | | | **Bay** - an indentation in the coast, smaller than a gulf, through which the sea penetrates inland.<br>**Inlet** - an indentation in the coast that is wide open in the direction of the sea, but with little sea penetration, or in other words, a bay in which two promontories appear at a distance from each other. |
| | | | **Cape** - in coastal topography, this is the name given to the protruding part of the coast at a regular altitude that juts out towards the sea. |
| | | | **Linear beach** - "sand deposits accumulated by fluvial or marine transport agents" of the linear type. |
| | | | **Arches** - epeirogenic movements of sections of the earth's crust, producing pumped arcs of great curvature, giving rise to uplifted areas. |
| | | **TECTONIC/ NEOTECTONIC** | **Folded structures** - characterized by the deformation of plastic rock material through tectonic effects in the geological layers, the resulting element of which is the fold. |

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| | | | **Faulted structures** - a type of fracture in which the rock blocks move in any direction (vertical or horizontal movements), parallel to the fracture surface.<br>**Fractured structures** - These are morphostructural features in which rocks are fragmented (fractured) due to the occurrence of tectonic forces (compression, distension, uplift) that exceed the limits of resistance of the materials. They can occur in all types of rock and fractures can be merely superficial or extend underground. There are also fractured structures of tectonic origin, formed mainly by external processes (temperature change, humidity change, pressure relief). |
| | | **PLUTONIC** | **Intrusive structures** - these are produced by the intrusion of magma and can appear on the surface both in the form of intrusive massifs and as phyllaries thanks to erosion. |
| | | **VULCANIC** | **Eruptive structures** - produced by the cooling of igneous material inside the earth as it moves towards the surface.<br>**Dikes** - Intrusion of magma in an elongated form through layers of the earth's crust.<br>**Veins** - Intrusions, constituting dikes, pegmatites or veins. They are sometimes distinguished from dykes and pegmatites by the way they are formed, with the material being deposited in the fissure very slowly. |
| | | **EROSIVE FORMS IN SEDIMENTARY STRUCTURES** | **Ruiniform relief** - forms of relief that occur as a result of differential erosion.<br>**Plateaus** - the name used in Brazil for the large, sometimes horizontal surfaces at altitudes of over 600 meters that appear in the Central-West Region of Brazil.<br>**Tablelands** - flat or tabular terrain.<br>**Canyons** - a name of Spanish origin used to designate valleys with abrupt walls, i.e. steep-sided valleys.<br>**Depressions** - area or portion of the relief situated below sea level, or below the level of nearby regions.<br>**Cuesta** - an asymmetrical landform consisting of a steep escarpment and a gentler (or later) slope. It is typical of areas covered by strata of varying strength that are dipping and sloping gently in one direction, and is intermediate between the mesa and the flat-topped butte, and the more symmetrical ridge form.<br>**Glint** - glint is the aclinal and continuous scarp formed by the discordant contact of a |

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| | | | sedimentary structure immediately above the eroded basement. |
| | | **FLUVIAL** | **Abandoned meander** - one that no longer has direct links to the current watercourse. |
| | | | **Waterfall** - a waterfall in the course of a river, caused by the existence of a step in the river's longitudinal profile.<br>**Cascade** - a succession of small jumps in a watercourse where blocks of rock appear. A cascade represents a certain break in the uniformity of the slope and is explained by the resistance offered by certain sills or rock banks that are more resistant to erosion. The waterfall recedes from downstream to upstream due to backwater erosion. |
| | | **GLACIAL** | **Glacial valley** - a valley carved out or taken over by a mountain glacier and which has a perpendicular U-shaped section, as opposed to river valleys which have a V-shaped profile.<br>**Fjord** - Long, narrow, deep, U-shaped coastal inlet that usually represents the seaward end of a glacial valley that has been partially submerged. The water depth usually exceeds 1,000 m, except near the mouth where a bar or sill may be present. |
| | **DEPOSITS** | **WIND** | **Dune fields** - mobile mounds of sand, deposited by the action of the prevailing wind.<br>**Paleodunes** - correspond to a stage in the process of evolution from loose sand to sandstone rock, a process that lasts thousands of years.<br>**Loess** - fine-grained aeolian sediment made up of quartz clay very rich in limestone. |
| | | **MARINE/FLUVIOMARINE** | **Barrier** - elongated island, strip or tongue of sand, deposited parallel to the coast thanks to the destructive and constructive dynamism of ocean waters.<br>**Barras** - banks or crowns of debris carried by watercourses and deposited at the mouths of rivers. |

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| | | | **Reefs** - generally coastal formations that appear close to the shore.<br>**Lagoons** - Depression containing brackish or salt water, located at the coastal edge.<br>**Marine Terraces** - A sedimentary deposit of marine origin located above the current mean sea level. |
| | | **FLUVIAL** | **River islands** - those surrounded only by fresh water, appearing in the bed of a river. Their origin can be linked to river sedimentation itself.<br>**Floodplain** - a surface that is not very high above the average water level and is often inundated during floods.<br>**Terrace** - a horizontal or gently sloping surface made up of sedimentary deposits, or a topographic surface shaped by river, sea or lake erosion and bounded by two slopes in the same direction.<br>**River bars** - banks or crowns of debris carried by watercourses and deposited at the mouth of rivers. Bars in rivers generally constitute a dangerous obstacle to navigation.<br>**Alluvial fans** - deposit of detrital material that appears below the flow channel of a torrent.<br>**Delta** - Alluvial deposit that appears at the mouth of certain rivers, advancing like a fan towards the sea.<br>**Estuary** - The way a river flows into the ocean, differently from the delta. The estuary forms a single mouth and is generally beaten by marine currents and tidal currents that prevent the accumulation of debris, as occurs in deltas. |
| | | **GLACIAL** | **Moraina** - Hill-like accumulation of poorly sorted glacial rock debris (till) on the sides or in front of a glacier.<br>**Erratic blocks** - fragments of rock transported by glaciers, sometimes weighing several tons.<br>**Glaciers** - masses of ice formed in regions where snowfall exceeds melting.<br>**Till** - unconsolidated elastic deposit originating from glacier transport. |

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| **DISSECTION FEATURES** | Hill - Small elevations of land with gentle slopes that are lower than hills. The altitude of hills does not exceed 50 meters.<br>**Spine** - The undulations of the terrain, which sometimes become more rugged and sometimes gentler. Some authors define it as a series of small hills, i.e. a series of humps.<br>**Crest** - Intersection of the plane of the slopes, it is the opposite of the talvegue. It consists of a line determined by the highest points, from which the two slopes diverge.<br>**Peak** - The highest point of a mountain or range. It usually has a pointed shape. Peaks are formed from harder rocks and, due to the selective effects of erosion, become prominent points in the relief. | |
| | **Plateau** - is a typical sedimentary plateau, as it is a stratified plateau, with a plateau characterized by escarpments and a considerable drop in altitude in relation to the surrounding relief.<br>**Escarpment** - a ramp or steep slope of terrain that appears on the edges of plateaus, mountains, cliffs, etc. | |
| | **Butte** - is a hill with a more or less flat top located in front of a cuesta escarpment, maintained by the most resistant layer.<br>**Crystalline Plateau/Massif** - large masses of eruptive or metamorphic rocks covering relatively large areas.<br>**Canyon** - a deep, narrow and long valley with vertical walls, cutting through highlands or mountainous regions, into which drainage normally flows.<br>**Valley** - a corridor or depression with a longitudinal shape (in relation to the contiguous relief), which can sometimes be several kilometers long. They are topographic forms made up of talvegues and two slopes with two converging slope systems. | |
| | **Cliff** - abrupt or steep coastal landforms, or similar unevenness in the interior of the continent.<br>**Tablelands** - flat or tabular terrain. | |
| **DEPOSITION FEATURES** | **Plain** - an expanse of more or less flat land where the processes of aggradation outweigh those of degradation.<br>**Colluvium** - material transported from one place to another, mainly by the effect of gravity. Colluvial material only appears at the foot of slopes or in places not far from slopes above them.<br>**Delta** - an alluvial deposit that appears at the mouth of certain rivers, advancing like a fan towards the sea. This deposition requires certain conditions such as the absence of marine currents, a shallow bottom, abundance of debris, etc.<br>**Beach** - deposits of sand accumulated by river or sea transport agents.<br>**Barrier** - strip or tongue of sand, deposited parallel to the coast, thanks to the destructive and constructive dynamism of ocean waters. | |
| | **Spit** - a tongue of sand and pebbles, arranged parallel, oblique or even perpendicular to the coast and sometimes extending underwater in the form of a bank.<br>**Dunes** - mobile mounds of sand, deposited by the action of the prevailing wind. The movement of the quartz grains is constant due to the action of the wind.<br>**Isthmus** - a narrow strip of land between two seas, generally corresponding to an area where the land has sunk or, conversely, the sea has invaded.<br>**Bay** - an indentation in the coast, smaller than a gulf, through which the sea penetrates into the interior of the land. | |
| **RESIDUAL FEATURES** | **MACROFORMS** | **Inselberg** - remnants of pediplanation in hot arid and semi-arid climates. Slightly elongated and relatively isolated |

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| | | elevations, which evolved as a result of an erosion system in a semi-arid climate.<br>**Butte** - the remains of old eroded surfaces. Important for geomorphology, thanks to them it is possible to reconstruct erosion cycles. They have a tabular shape when the structure is horizontal and a crest shape when inclined.<br>**Ridge** - intersection of the plane of the slopes, it is the opposite of the talvegue. It consists of a line determined by the highest points, from which the two slopes diverge.<br>**Escarpment** - a ramp or slope of land that appears on the edges of plateaus, mountains, cliffs, etc.<br>**Lajedo** - outcrop of healthy rock on the surface of the ground, constituting an area of variable extent.<br>**Bornhardt** - Also known as dome inselbergs, they have concave-convex slopes and are made up of solid rock, with few structural discontinuities, little regolith, generally with bare slopes and a flat top. It is important to note that inselberg and bornhardt are not equivalent. Therefore, many inselbergs are bornhardts, but not all bornhardts are inselbergs. |
| | **MICROFORMS** | **Boulder** - Boulders can be visualized as the most resistant rock compartments (corestones). These can be exposed as boulders once the weathering mantle covering them has been removed.<br>**Castle Koppies** - Castle koppies tend to have an angular outline that reflects the pattern of widely spaced and well-developed orthogonal fractures. This fracturing pattern can generate foci of resistance, conditioning the appearance of castle koppies, producing a stacking of blocks.<br>**Block chaos** - The advance of exfoliation [a slow, continuous process] leads to instability, with the detachment of rock slabs that collapse and give rise to coarse residual deposits of the block chaos type, which are generally carried by gravity to the base of the Inselberg or Bornhardt.<br>**Tors** - The name comes from the Welsh word twr or twrr, which means mound or pile. Tors can be defined as isolated outcrops of rock and are ubiquitous landforms in granite terrain. |

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| | | **Tafoni** - Tafoni are polygenic and polyform cavities that form from the expansion of a core that is progressively consumed by weathering.<br>**Honeycomb** - a type of cavernous weathering, small alveoli, only a few centimeters wide and deep, which are developed so closely that they are separated by a narrow wall only millimeters thick, similar to a honeycomb.<br>**Karren** - The karren organizes the runoff dispersal system, creating drainage foci. Sometimes they accumulate sediment and organic debris in their interior, allowing vegetation access to the escarpments and tops of the inselbergs.<br>**Gnammas** - These are small, closed depressions, morphologically they vary in shape and size, and can be circular, elliptical or oval, with a diameter of around one meter and a depth of perhaps 0.5m.<br>**Split Rock** - Occurs when boulders are split into two or more parts as a result of the development of fractures.<br>**Polygonal Cracking** - Some boulder surfaces and rock outcrops exhibit networks of shallow cracks that describe polygons of varying geometry. Where cracking is well developed, rock surfaces have the appearance of a turtle shell or crocodile skin.<br>**Pedestal rock** - These are characterized by consisting essentially of two parts: a narrow pillar or shaft that supports a much larger top, the narrowing of the lower part of which is the result of more efficient weathering on the subsurface. |
| | **PLUVAL ACTIONS** | **Thermoclasis** - temperature fluctuations between day and night cause successive |

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| **APPARENT MORPHODYNAMIC PROCESSES** | | alternations of rock expansion and contraction.<br>**Corrosion** - work done by the wind (aeolian erosion) destroying the most prominent parts and accumulating in the relatively lower areas.<br>**Flaking** - the formation of peels or scales on a rock, produced by weathering.<br>**Dissolution** - calcium carbonate in contact with water loaded with carbonic acid changes into calcium bicarbonate; rock salt, for example, also changes in contact with water.<br>**Diffuse flow** - water flows in a dispersed manner, not forming streams.<br>**Gully** - small furrows or gullies that cut through the rocks, usually in the direction of the slope.<br>**Erosion furrows** - incisions formed in the soil as a result of concentrated surface runoff.<br>**Ravine** - furrows produced in the land due to the erosive work of run-off water.<br>**Gully** - an excavation or tear in the soil or decomposed rock caused by the erosion of surface runoff. They can also be formed by subsurface runoff.<br>**Torrent** - periodic watercourses produced by torrents, sometimes very violent. |
| | **MASS MOVEMENTS** | **Reptation** - the slow displacement of soil particles due to variations in temperature and humidity, which contributes to increasing the plasticity of the soil. Another factor contributing to displacement is the freezing and subsequent thawing of the water contained in the soil.<br>**Solifluction** - movement of a certain mass of soil or decomposed rock soaked in water. It occurs as a result of melting snow or melting ice, or because of persistent rainfall.<br>**Landslides** - the collapse of slopes caused by the deepening of river channels and erosion of the banks of watercourses.<br>**Mudflow** - the movement of a mass, usually clay, impregnated with water. This material descends due to the effect of gravity and water, which act as a lubricating agent.<br>**Landslides** - displacement of soil masses over a water-saturated base. Landslides depend on various factors, such as: slope inclination, amount and frequency of rainfall, presence or absence of vegetation, consolidation of the material, etc.<br>**Falling blocks** - these are sudden movements of geological material (blocks of rock, |

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| | | pebbles, sand, etc.) that has become loose due to weathering or other causes. |
| | **FLUVIAL ACTIONS** | **Corrosion** - the phenomenon of rock destruction due to chemical decomposition by running water.<br>**Corrasion** - the process of physical wear and erosion of rocks, mainly through the impact and/or friction of particles and fragments transported by wind (aeolian), water (fluvial, tidal, current) or ice (glacial).<br>**Transport** - the loading of sediment by river water.<br>**Accumulation** - the same as sedimentation. The process by which sediments or substances that could be mineralized are deposited. |
| | **WIND ACTIONS** | **Transportation** - the phase of erosion that follows the action of destruction carried out by exogenous agents. In a broader definition, transportation can be said to be the whole set of geological phenomena that cause the mass of soil and rock to move from one point to another. In this case, it is exerted by the action of the wind.<br>**Deposition** - accumulation of material transported and deposited by the wind.<br>**Erosion** - the process of physical wear and erosion of rocks mainly through the impact and/or friction of particles and fragments transported by wind (aeolian), water (fluvial, tidal, current) or ice (glacial). |
| **OTHER COMPONENTS OF THE LANDSCAPE** | | |
| **SOIL AND SURFACE FORMATIONS** | **NATURE OF THE MATERIAL** | **Eluvial** - detrital deposit or simple layer of debris resulting from the disintegration of the parent rock, remaining in the place of formation.<br>**Colluvial** - accumulation of material often located at the foot of a slope and transported by gravity.<br>**Alluvial** - accumulation of material carried by river water. The stratification of alluvial deposits in a delta is quite different from that found on a terrace.<br>**Marine** - sediments accumulated at the coastal edge or in deeper regions. Sometimes these deposits appear above the current level of the seas, due to oscillations between land and ocean levels.<br>**Aeolian** - accumulation of material transported and deposited by the winds. |

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| | **SOIL EROSION** | **Pluvial** - work done by rainwater on the surface of the land.<br>**Laminar** - when rainwater runoff "washes" the soil, i.e. removes its surface cover and wears it down.<br>**Furrows** - incisions formed in the soil as a result of concentrated surface runoff.<br>**Ravines** - excavation produced by surface runoff when it undergoes certain rill-erosion concentrations.<br>**Fluvial** - continuous and spontaneous work of running water on the surface of the earth.<br>**Marine** - the work of destruction and construction carried out by forced or translational waves along coastlines.<br>**Wind** - work done by the wind, most important in desert regions, semi-arid areas or coastal areas. The morphological landscape of dunes results from the transportation of sand grains by the wind. Wind erosion gives rise to typical forms.<br>**Deflation** - work carried out by the wind on the surface of rocks, carrying debris broken down by mechanical erosion. |
| **LANDSCAPE ANALYSIS** | | |
| **MEDIA ECODYNAMICS** | **Stable environment** - predominantly pedogenesis. Media with slow evolution, closed vegetation cover, moderate dissection and absence of volcanic manifestations.<br>**Transitional environment with a tendency towards stability** - when pedogenesis slightly outweighs morphogenesis.<br>**Transitional environment with a tendency towards instability** - when morphogenesis slightly outweighs pedogenesis.<br>**Strongly unstable environment** - predominance of morphogenesis. Environments where geodynamics has intervened through volcanism, tectonic deformations and anthropogenic instability. | |

*Source: Tricart (1977), Guerra e Guerra (2005), Souza (2000), Andrade (2003), CPRM (2008), Allaby (2008), ICMBio (2011), Gray (2013), Gray, Gordon, Brown (2013), Silva (2016), Peulvast e Vanney (2001) and Winge et al. (2001).*

## 4. Conclusions

The form presented above was developed based on various authors, was applied repeatedly throughout the development of the dissertations by Araújo (2021), Terto (2021), Silva (2022) and Costa (2022), and was improved with each application. The article by Diniz, Araújo and Chagas (2022) used the form for qualitative assessment, serving as the basis for the development of quantification carried out for the coast of Icapuí - CE. The methodology was also useful in developing the field activities of four master's dissertations by this research group. All four were awarded merit during their defense by the evaluation boards. The expectation is that the dissemination of the form through the Revista de Geociências do Nordeste (Northeast Geosciences Journal) will help support other studies that assess Geoheritage in the academic and technical environment.

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